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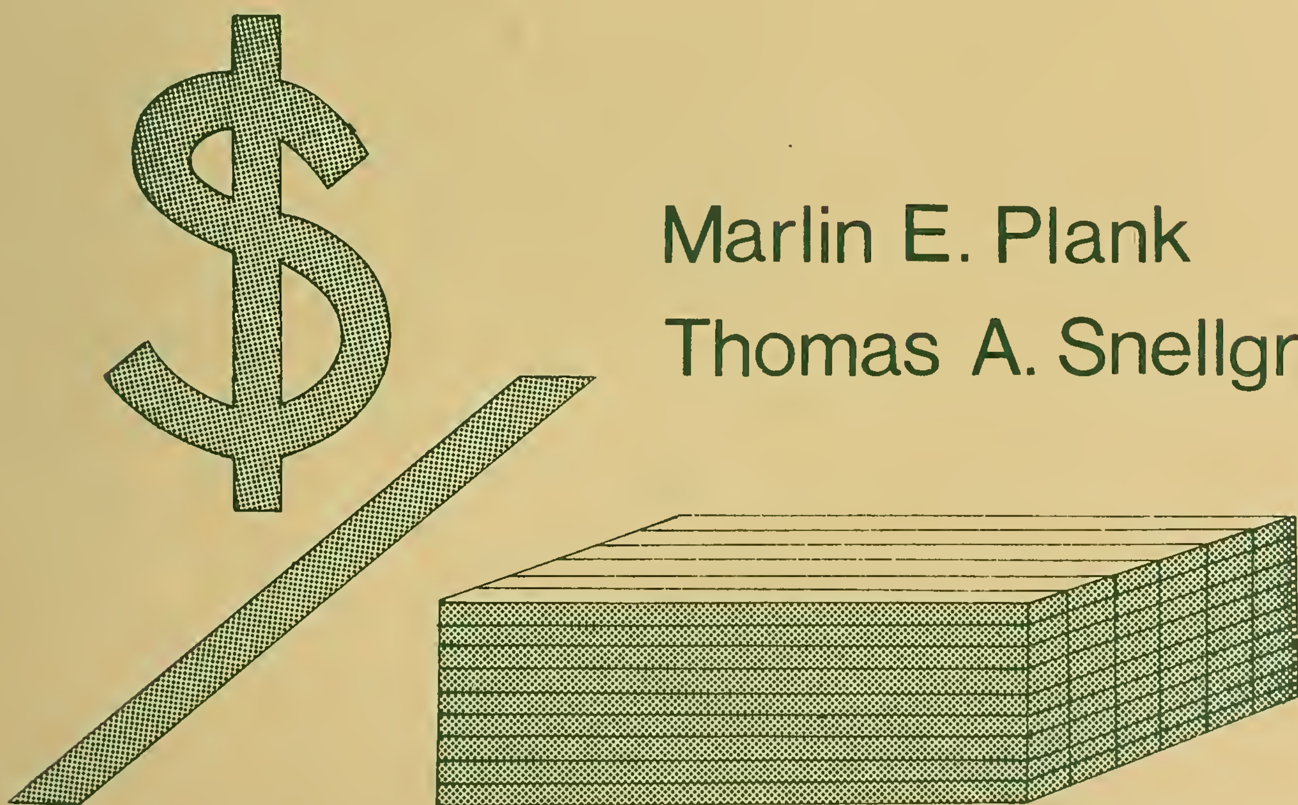
1978

An Equation For [ESTIMATING The (VALUE And / VOLUME) Of (Western Larch Trees)]



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AN EQUATION FOR ESTIMATING THE VALUE AND VOLUME OF WESTERN LARCH TREES

Reference Abstract

Plank, Marlin E., and Thomas A. Snellgrove.
1978. An equation for estimating the value and volume of western larch trees. USDA For. Serv. Res. Pap. PNW-231, 29 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

This paper describes an equation for estimating the total sales value or the volume for western larch trees. The equation requires four easy-to-measure characteristics. Both the development and the application of the system are discussed.

KEYWORDS: Tree value, volume estimation, grading systems, western larch, *Larix occidentalis*.

RESEARCH SUMMARY

Research Paper PNW-231

1978

This paper describes a system for estimating the lumber selling value and the total volume of western larch trees in a manner which is more accurate and more practical to apply than the conventional method of placing logs in discrete classes.

From a total sample of 576 trees selected from 21 different areas in northeastern Washington and northwestern Montana, 506 were used to develop a prediction model equation. The remaining 70 trees plus 100 trees from a followup study in northwestern Montana were used to test the equation.

The model contains four tree characteristics:

1. tree diameter,
2. tree height,
3. the number of limb-free and defect-free faces in the butt 16-foot log, and
4. total tree defect.

The prediction equations account for 86 percent of the total variation in tree value and 89 percent of the total lumber volume variation as measured by the R^2 values.

When the system was applied to the 70 trees withheld from the original data, the prediction was 2.8 percent above the actual total dollar value and 1.8 percent above the volume recovered in lumber. The supplemental 100-tree study showed a predicted value of 2.7 percent less than the actual, and the volume estimate was 0.9 percent greater than that actually recovered.

The system is faster and more objective than log grading, and training and checking of cruisers is easier.

Introduction

This paper is a continuation of a successful effort to improve methods of estimating the value and volume of sawtimber in the Western United States. A system is described which estimates the lumber selling value or volume of western larch (*Larix occidentalis* Nutt.) trees in a manner which is simpler and easier to apply than the conventional method of placing logs in discrete classes.

Two other papers[1/] describe similar systems which are now being used to appraise Inland Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western white pine (*Pinus monticola* Dougl.). These papers document the advantages of using a continuous variable system; likewise they show a number of reasons why the method of using discrete log grades is often inadequate.

The following describes the system, its development, and illustrates its performance with western larch.

Study Procedures

SAMPLE

This tree grading system was developed by studying the quality-related characteristics and lumber yield from two western larch lumber recovery studies. These studies were conducted in northwestern Montana and northeastern Washington (fig. 1). The Montana study included 297 trees selected from 11 areas on the Flathead National Forest. This resulted in 1,469 sawn logs with a lumber tally volume of 187,303 board feet. In the Washington study, 279 trees were selected from 10 areas on the Okanogan National Forest and the lumber yield from the 1,341 logs was 201,092 board feet.

The sample areas were chosen to represent differences in tree size, stem quality, and site characteristics. Within each sample area, individual trees were selected on the basis of d.b.h. The average d.b.h. and height for the trees in the Montana study area were 19.8 inches and 109 feet. For the Washington study, average d.b.h. was 23.5 inches, and average height was 113 feet. Over both samples, the d.b.h. range was from 8 to 43 inches. The study trees were felled and bucked into saw logs according to normal industry practice. The visible surface characteristics of each log were recorded in detail after the logs were spread out in the mill yard.

[1/] Lane, Paul H., Marlin E. Plank, and John W. Henley. 1970. A new and easier way to estimate the quality of Inland Douglas-fir sawtimber. USDA For. Serv. Res. Pap. PNW-101, 9 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Snellgrove, Thomas A., Marlin E. Plank, and Paul H. Lane. 1973. An improved system for estimating the value of western white pine. USDA For. Serv. Res. Pap. PNW-166, 19 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Figure 1.--Range of western larch (shaded) and general locations (cross-hatched) of the 21 areas from which study trees were cut.

The study logs were processed at two sawmills which were considered representative of those processing western larch. The logs were sawn under normal production conditions, that is, sawing the particular mill's usual lumber items with the intent of obtaining the highest value from each log. The lumber tally values and volumes were based on kiln-dried, surfaced lumber tally according to general industry practice.

DEVELOPING THE PREDICTION MODEL

The determination of those tree characteristics most highly correlated with total value and volume of lumber began with the screening of 62 variables. Previous studies on other species have indicated which variables or combinations should be included in the screening process. A list of the independent variables that were examined can be found in appendix I. The principal methods used were the forward stepwise regression procedure and all possible regressions. The stepwise regression procedure was used to identify those individual tree characteristics that best represented the factors of tree volume, defect, and quality, and which were correlated with tree value or tree lumber tally volume. After this screening, the independent variables that had little or no correlation with tree value or volume or were too difficult or impossible to quantify in cruising were

omitted from further analysis. The remaining variables, along with alternative forms of the same variable, were further screened by means of the all possible regression procedure to choose the final variables for the model.

As previously mentioned, two separate studies were conducted. Separate analyses of the two studies were done concurrently. The same variables surfaced as being the most practical for application in timber appraisals and statistically accounting for the most variation in lumber volume and value. Consequently, the same model was chosen for the two studies.

Although the regression equations were statistically different for the two studies, a common regression was fitted to the data from both. A common regression line was chosen to provide a broader inference to the entire range of western larch, and the difference between the regression equations for the two studies is probably not of practical significance.

Four measurable characteristics survived as the most practical for application in timber appraisals and accounted for the most variation in lumber volume and value. They are:

1. tree diameter at breast height,
2. total tree height,
3. number of limb- and defect-free faces on the butt 16-foot log, and
4. estimated tree defect expressed as a percentage of gross volume.

These four characteristics together with several transformations[2/] of the same characteristics were selected as the best independent variables for the model. These variables along with lumber yield information were used to develop the regression equations for predicting total tree value (dollars) and lumber tally volume (board feet) on a tree basis. Total tree value (dependent variable) is determined by multiplying the lumber yield data found in appendix II by an appropriate price.

The following model equations are used for predicting total tree value and total lumber volume:

$$\text{Total tree value} = b_o + b_1(DEF)(D^2H) + b_2(NLDF16) + b_3(D) + b_4(H) + b_5(DEF^2)(D^2H) + b_6(D^2) + b_7(H/D) + b_8(D^2H)$$

[2/] Transformations are constructed variables designed to account for interactions of independent variables, e.g., height over diameter (H/D).

$$\text{Total lumber volume} = b_o + b_1(DEF)(D^2H) + b_2(NLDF16) + b_3(D^2) + b_4(H) + b_5(DEF^2)(D^2H) + b_6(H^2) + b_7(H/D) + b_8(H/D)^2 + b_9(D^2H) \quad ;$$

where, b_o is the Y intercept constant,
b_i is the regression coefficient where i goes from 1 to 9,
D is tree diameter at breast height (inches),
H is total tree height (feet),
NLDF16 is the number of limb-free and defect-free faces in the 16-foot log, and
DEF is the estimated tree defect expressed as a percentage of gross cruise volume.

Coefficients for the value equation may be determined according to the steps in the section: How to Use the System.

Coefficients for the volume equation are as follows:

Constant	= + 80.453880
$(DEF)(D^2H)$	= - .000088720520
NLDF16	= + 2.4064027
D^2	= + .67704661
H	= - 5.5433410
$(DEF^2)(D^2H)$	= - .00000041939578
H^2	= + .033906473
H/D	= + 8.9652163
$(H/D)^2$	= + .077834676
(D^2H)	= + .0083360138

The equations developed from the two lumber recovery studies account for 86 percent of the total variation in total dollar value, 89 percent of the total variation in lumber volume.

How the System Performs

From the total sample of 576 trees, a subsample of 70 trees was randomly selected to test the performance of the estimating equations. The 70 trees were not used in the development of the equations. The four quality criteria measurements (d.b.h., height, faces, and defect) were recorded for each of the 70 trees. Predictions of the lumber selling value and lumber tally volume were then calculated.

Table 1 shows comparisions of estimated and actual values for the 70 test trees. Plots of the actual versus estimated tree values and volumes of individual trees are

Table 1--*A comparison of estimated and actual lumber selling value and lumber tally volume for 70 western larch trees*

Unit	Estimated	Actual	Percent difference
Total value (dollars)	3,429.96	3,337.23	+2.8
Total lumber tally volume (board feet)	47,913	47,068	+1.8

shown in figures 2 and 3. As shown in these figures, the estimates of value and volume are about equally split by the 45-degree line.

In 1971, a lumber recovery study was held in Troy, Montana, in which the four quality criteria were recorded for each of the 100 trees in the sample. Predictions of the lumber selling value and lumber tally volume were made using the coefficients developed from the two base studies.

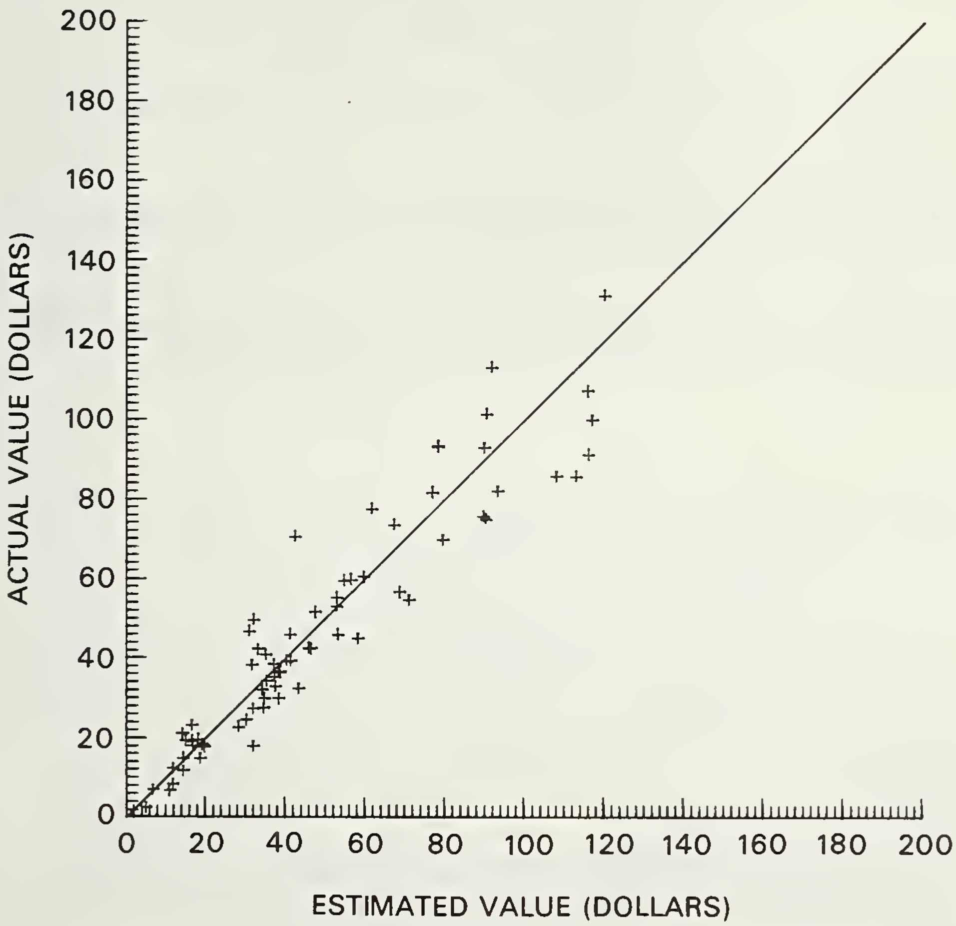

Figure 2.--Plot of actual overestimated tree value. 70-tree sample.

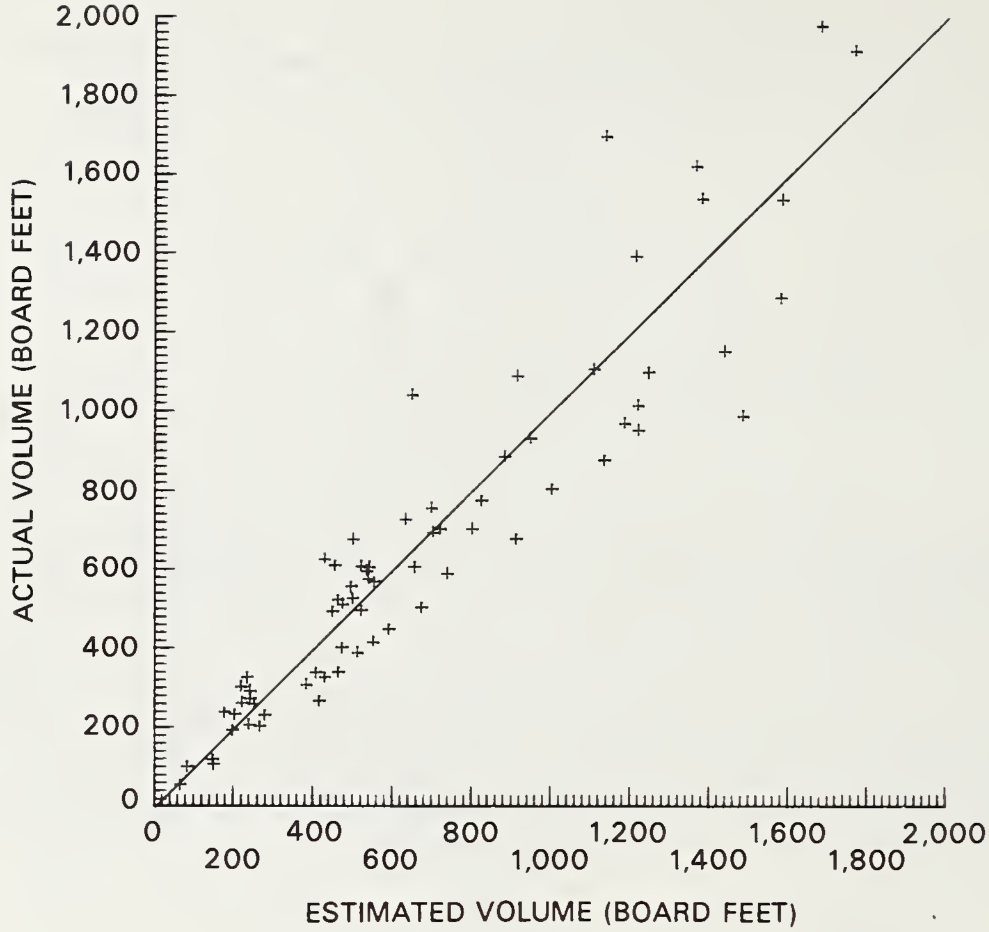

Figure 3.--Plot of actual overestimated tree lumber tally volume. 70-tree sample.

Table 2 shows the comparisons of the estimated and actual values for the 100 trees.

Figures 4 and 5 show plots of the actual versus estimated values and volumes for those trees.

Table 2-- *A comparison of estimated and actual lumber selling value and lumber tally volume for 100 western larch trees*

Unit	Estimated	Actual	Percent difference
Total value (dollars)	4,123.44	4,239.29	-2.7
Total lumber tally volume (board feet)	53,624	53,159	+0.9

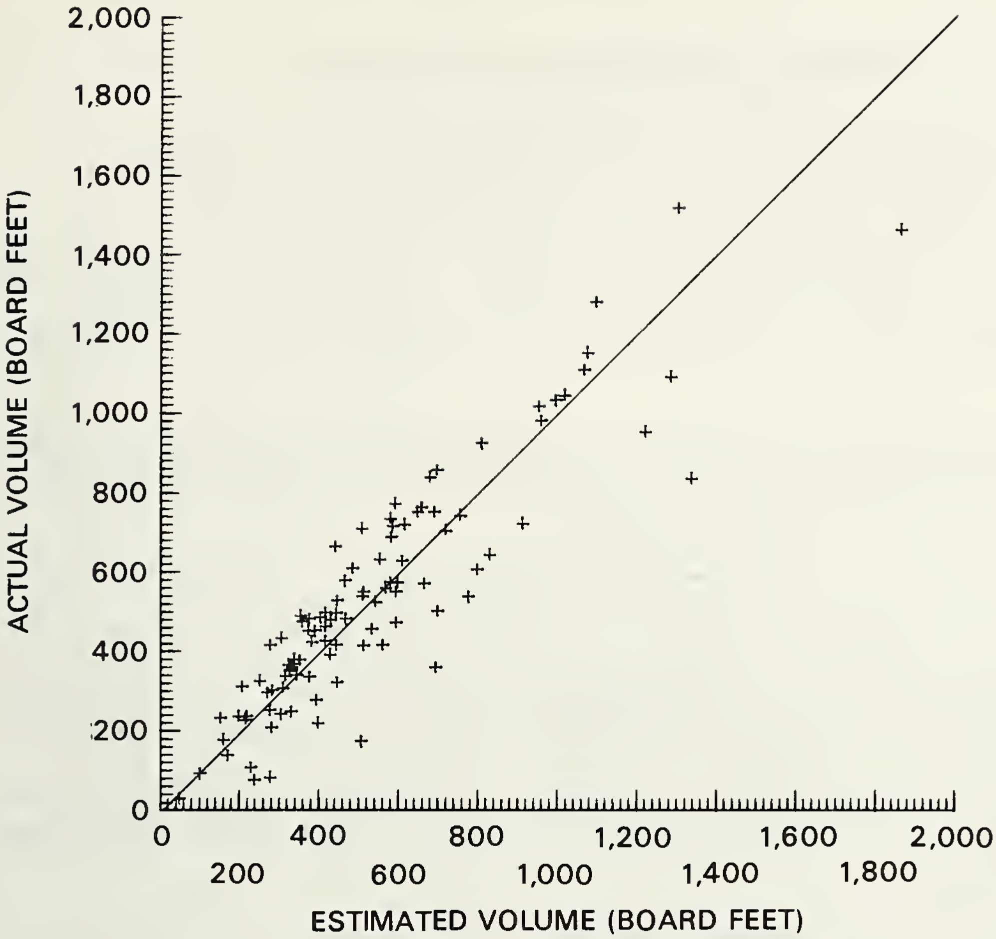

Figure 4.--Plot of actual over-estimated tree lumber tally volume. 100-tree sample.

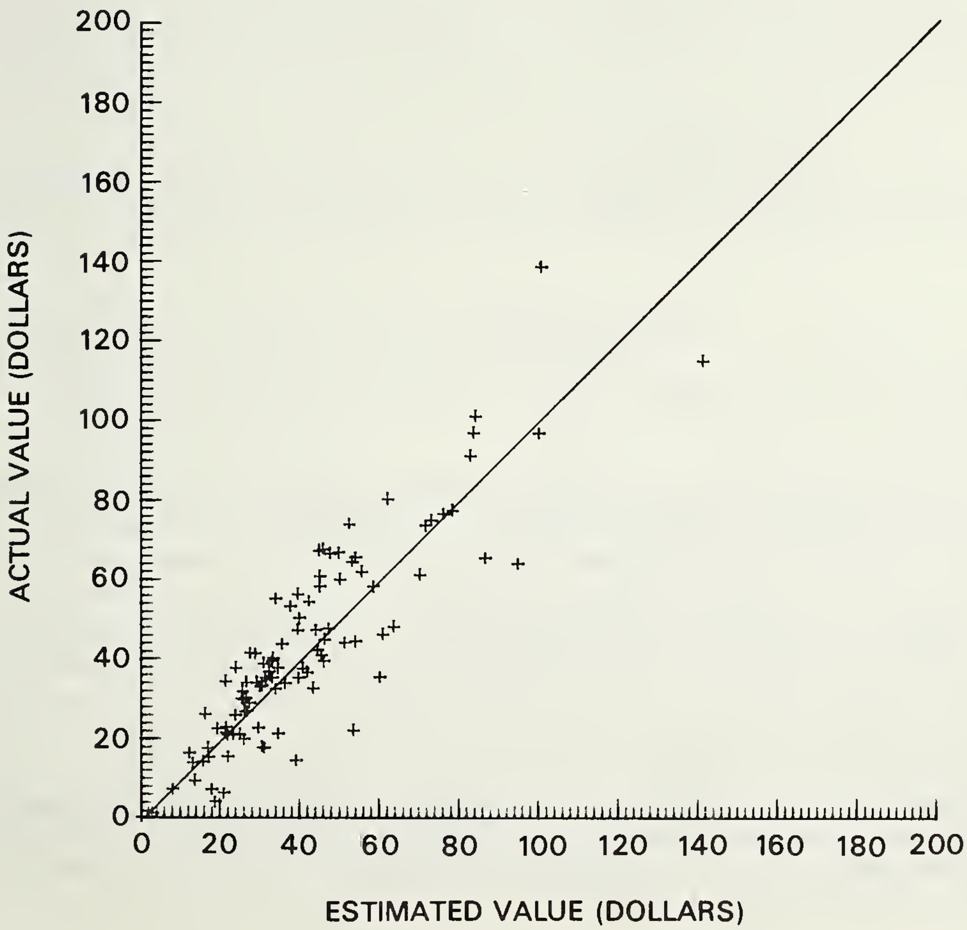

Figure 5.--Plot of actual over-estimated tree value. 100-tree sample.

How to Use the System

Efficient use of this system requires computer facilities for making regression analyses. The tree characteristic data (the four quality criteria), the lumber grade yield data for each of the trees in the base study, and appropriate prices are needed in a form suitable for computer use. A listing of the data and the card format for the 506 trees is illustrated in appendix II.

To estimate the total lumber tally volume of a tree or group of trees, simply solve the following equation using the coefficients shown:

$$\text{Total lumber tally volume (board foot)} = +\ 80.453880 - .000088720520(DEF)(D^2H) + 2.4064027(NLDF16) + .67704661(D^2) - 5.5433410(H) - .0000004193957 8(DEF^2)(D^2H) + .033906473(H^2) + 8.9652163(H/D) + .077834676(H/D)^2 + .0083360138(D^2H).$$

The step-by-step procedure for estimating the selling value for a group of trees such as a sample for appraisal is as follows:

1. Select sample trees.

2. Measure and record for each sample tree the four characteristics:

   a. Tree diameter,
   b. Tree height,
   c. Number of limb-free and defect-free faces in the butt 16-foot log, and
   d. Tree defect.

3. Assign current or desired lumber price(s) such as those available from several industry price reporting services to each of the lumber grades recorded in the original base study.

4. Multiply these lumber prices by the lumber yield information shown in appendix II to obtain a total dollar value for each of the trees that are in the base study(s).

5. Use an appropriate multiple regression program such as the BMD program series[3] to develop the value equation coefficients for the 506 trees. Use the computed

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[3] Dixon, W. J., ed. 1964. BMD biomedical computer programs. Health Sciences Computing Facility, Department of Preventative Medicine and Public Health, School of Medicine, University of California at Los Angeles, Calif.

total dollar value (step 4) and the four tree characteristics and the following transformations:

Dependent Variables:

Total dollars/D^2H.

Independent Variables:

DEF
DEF^2
$NLDF16/D^2H$
D/D^2H
H/D^2H
D^2/D^2H
$H/D/D^2H$
$1/D^2H$

The dependent variable is divided by D^2H to equalize variance, and all of the independent variables except DEF and DEF^2 are divided by D^2H so that when the equation is untransformed it will appear as that on page 3 and 4. DEF and DEF^2 are not divided by D^2H because they are already expressed as a percent of total volume.

6. Make a covariance analysis of the two base study value equations that result from applying new prices to obtain appropriate coefficients for the common equation (i.e., to obtain the weighted average equation applicable to the two base studies). If base studies are to be applied individually, use the appropriate equation for each area.

7. Solve the value equation for the selected sample trees in step 1 using coefficients developed in step 6.

Conclusions

Field application tests of the system have demonstrated that it has a number of advantages over the conventional log grading method. It is faster to apply and thus more economical; it contains fewer judgment factors and therefore requires less experience by the cruiser and simplifies the training and checking of cruisers. Selling price is computed directly, the significant quality characteristics of each sample tree are recognized, and the computation procedures are relatively simple.

This system is similar to others which have been used successfully by the U.S. Forest Service in computing selling value on commercial timber sales in the northern Rocky Mountains. The performance and acceptance by both timber buyers and sellers indicate these systems are relatively

simple yet accurate methods for estimating the quality of sawtimber. The tests conducted thus far indicate that this system is applicable throughout the Inland Empire. Due to the expanse of the sample, it is the authors' opinion that it could be applied throughout the entire range of western larch.

Appendix I

INDEPENDENT VARIABLES

Defect related variables

1. defect percent
2. defect percent squared

Presence or absence of:

3. bumps and burls
4. burls over 4 inches
5. conks
6. basal wounds
7. nonbasal wounds
8. all wounds

Length of:

9. basal wounds
10. nonbasal wounds
11. all wounds
12. basal wounds squared
13. nonbasal wounds squared
14. all wounds squared
15. total diameter of burls
16. total number of conks
17. total number of conks squared
18. number of knot clusters in butt 16-foot log
19. number of knot clusters in butt 32-foot log

Quality related variables

20. height to the first dead limb
21. height to the first live limb
22. size of the first dead limb
23. size of the first live limb
24. size of the largest limb in the butt 16-foot log
25. size of the largest limb in the butt 32-foot log
26. height to the start of the crown
27. crown ratio
28. crown length
29. height of clear bole allowing no defect
30. height of clear bole allowing defect
31. height of limb-free bole allowing no defect

32. height of limb-free bole allowing defect
33. total length of clear face in 4-foot minimum units in the butt 16-foot log
34. total length of clear face in 4-foot minimum units in the butt 32-foot log
35. total length of clear face in 8-foot minimum units in the butt 16-foot log
36. total length of clear face in 8-foot minimum units in the butt 32-foot log
37. number of 4-foot clear panels on the butt 16-foot log
38. number of 4-foot clear panels on the butt 32-foot log
39. number of clear 8-foot panels on the butt 16-foot log
40. number of clear 8-foot panels on the butt 32-foot log
41. number of clear 8-foot panels on the butt 16-foot log not allowing defect
42. number of clear 8-foot panels on the butt 16-foot log allowing defect
43. number of clear faces on the butt 16-foot log allowing defect
44. number of clear faces on the butt 16-foot log not allowing defect
45. number of clear faces on the butt 32-foot log allowing defect
46. number of clear faces on the butt 32-foot log not allowing defect
47. number of limb-free faces on the butt 16-foot log allowing defect
48. number of limb-free faces on the butt 16-foot log not allowing defect
49. number of limb-free faces on the butt 32-foot log allowing defect
50. number of limb-free faces on the butt 32-foot log not allowing defect

Volume related variables

51.	d.b.h. - D	57.	H/D
52.	total height = H	58.	D^2
53.	16-foot form class	59.	H^2
54.	taper	60.	$(D/H)^2$
55.	DH	61.	$(H/D)^2$
56.	D/H	62.	$1/D^2H$

Appendix II

TREE QUALITY CHARACTERISTICS AND LUMBER YIELD DATA

The tree quality characteristics and lumber yield data for each of the 576 trees from the two base studies are listed according to the card format shown below.

LIST OF CHARACTERISTICS

Columns	Data
1	study identifier
2-4	tree number
5-7	d.b.h.
8-10	total height
11-13	defect percent
14	number of limb-free and defect-free faces in the butt 16-foot log
15-18	volume of B Select lumber
19-22	volume of C Select lumber
23-26	volume of D Select lumber
27-30	volume of 1 Common lumber
31-34	volume of 2 Common lumber
35-38	volume of 3 Common lumber
39-42	volume of 4 Common lumber
43-46	volume of 5 Common lumber
47-50	volume of Select Structural lumber
51-54	volume of Construction lumber
55-58	volume of Standard lumber
59-62	volume of Utility lumber
63-66	volume of Economy lumber
67-72	total lumber tally volume

LIST OF DATA CARDS

			TOT	PCNT		VOLUME													
STUDY	TREE	DBH	HT	DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
1	1	306	150	12	4	80	205	212		8	186	116	7	80	139	607	301	109	2050
1	2	225	129	12			24	33		3	57	70	17		202	109	94	198	807
1	4	227	132	14	3		32	51			45	16		32	128	211	131	39	685
1	5	336	148	49	2	11	112	308			147	86	32		154	101	102	126	1179
1	6	235	110	11	3		8	30			30	17	19		100	285	157	120	766
1	7	202	120	6	2	9	36	44			36	58	10	27	277	37	57	71	662
1	8	146	94	13	4		5	8		7	5	9	5		118	23	11		191
1	9	273	147	12	4	21	132	101			72	48	8	112	296	183	192	172	1337
1	10	173	115	11	3		8	26		17	38	40	4		140	123	26	24	446
1	11	162	108	4	3		19	16				36	32		73	91		68	335
1	12	239	114	4	4	12	13	26		22	70	25	5		128	228	73	34	636
1	13	201	112	11	3		13	21			85	37			133	92	102	64	547
1	14	196	109	14	4		8	19		11	21	29	13		33	114	135	123	506
1	15	183	114	13	3			59			58	45			107	113	100	43	525
1	17	233	128	22	4		13	37			54	5	5		272	110	126		622
1	18	213	122	10	4		38	110		13	70	42	3	16	283	185	59	17	836
1	19	212	110	15	4			49			44	32		21	173	198	127		644
1	20	161	103	22	3		4	8			19	26	4		20	40	144	43	308
1	21	260	128	8	4		30	100		24	105	111	26		267	223	243	123	1252
1	22	136	90	14	4		8	5			12	20			53	16	46	32	192
1	23	247	114	7	3		53	48		18	71	150	15		195	133	84	48	815
1	24	205	122	10	3	11	34	14		11	55	31	28	101	139	58	38	16	536
1	25	163	113	6	4			8		8	62	25	10	21	217	63	75		489
1	26	176	97	12	3		8	29			19	45	4	59	59	50	81	19	373
1	27	174	92	3	2		34	24			32	71	19		77	77	56	68	458
1	29	238	110	10	4	54	64	124		24	51	11		123	234	138	20		843
1	30	227	120	16	4		60	69			56	61		21	212	141	98	99	817
1	31	228	112	6	3	13	16	79		26	47		9	53	245	230	79	16	813
1	32	223	108	6	3		23	110			30	42	30	48	149	156	94	30	712
1	34	188	102	17	4		21	49			33	28	20		21	32	136	81	421
1	35	226	137	20	2		55	61		24	70	29	46	21	199	136	30	45	716
1	38	171	99		3	27	8	13		24	53	12	3		215	56	48	12	471
1	39	162	94	14	3			22			30	27		32	126	82	37	9	365
1	40	192	98	27	4		27	18			33	25		16	74	137	37	27	394
1	41	225	92	7	3		16	28		3	22	20	13	11	235	24	83	87	542
1	42	241	140	13	2	30	92	36		30	59		18	64	124	155	208	62	878
1	43	258	136	6	4	43	147	128		21	83	31		27	236	171	74		961
1	44	207	106	13	4	11	19	56		11	25	48			150	118	41	141	620
1	45	201	103	5	4		15	74		22	41	16	18	32	169	89	58		534
1	46	207	100	10	4		11	63		21	22	55	13	43	130	125	103	20	606

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	VOLUME B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
1	47	280	132	13	3	60	198	134			143	52	16	33	300	242	272	16	1486
1	48	302	112	46	3	7	6	14			53	64	19		89	152	543	407	1354
1	49	149	84	4	4		20	33		11	29	15		11	59	91	41		310
1	50	153	92	32	2			5			15	4	3		16	22	38	52	155
1	51	194	91	45	2			4					7			11	8	87	117
1	52	255	100	14	4		38	58			82	31	8		197	348	160	63	985
1	53	190	92	13	4		33	37		38	17	29	15	32	107	96	59	43	506
1	54	194	89		4		13	47		24	46	12	2	16	207	106	63	27	563
1	55	106	70	20	3			9				4	3		7	16		14	53
1	56	137	76	8	4		10	19			16	8	5		76	16	16	8	174
1	57	152	72	42	4	3	18	7		5	5	11			32		16	24	121
1	58	186	88	19	4	.	6	40			32				43	125	53		299
1	59	181	87	9	4		26	27			5	66	8		90	100	106	59	487
1	60	256	98	10	4		16	73			66	33		32	96	223	346	66	951
1	61	194	93	5	4		18				50	28	16		203	53	65	7	440
1	62	216	95	4	3		37	69			37	23		91	155	179	120		711
1	63	207	90	15	3	7		33		13	70	19	3		115	224	154	14	652
1	65	197	89		4			9			8	2	1	8	12	33	24	4	574
1	66	132	80	25	3			14			14	8	10		35	34	43	22	180
1	67	209	87	12	4		9	47			30	17		9	102	180	152	63	609
1	68	264	100	16	4	31	51	101		11	107	83	13	37	123	130	164	74	925
1	69	253	96	10	4	8	44	91		11	84	58	23		135	293	130	90	967
1	70	262	104	17	4	21	40	111			118	67	30	16	133	202	277	51	1066
1	71	302	106	59	4		7	105			43	23			32		96	75	381
1	72	207	92		3		24	20			20	62	5	21	53	37	198	71	511
1	73	151	85	16	1			11			40	17			16	42	88	27	241
1	74	265	145	12	4	23	20	155			134	25	8	96	379	317	101		1258
1	75	231	139	1	3		20	19			183		15	155	296	243	143	32	1106
1	76	177	126	9	4			16		13	37	16			276	121	65	16	560
1	77	255	146	6	3	5	55	212			205	17		143	395	151	191	20	1394
1	78	204	140	14	4	11	33	58		7	73	60	10	58	185	117	147	54	813
1	79	257	144	15	4	13	32	158		27	115	27		21	225	228	170	28	1044
1	80	135	114		3		6	15		7	22	34		11	144	44	73	11	367
1	82	249	134	5	4		55	101		17	118	25			482	154	173	29	1154
1	83	125	100	8	3						16	7	10	9	65	46	29	9	191
1	84	194	126		4		38	43		11	120	26	10	59	182	96	53	11	649
1	85	244	137	9	3			62			175	21	9		187	284	474	24	1236
1	86	106	96		4							3	5	11	11	22	11	9	72
1	87	214	135	5	4		57	153			41	23	18	48	195	140	170	22	867
1	88	233	131	6	4	11	55	112			52	21	24	96	361	260	36	5	1033

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	VOLUME B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
1	89	247	137	5	4		21	101		13	78	24	8	21	177	152	178	27	800
1	90	226	130	13	4		5	46			145	33		80	310	149	52	64	884
1	91	354	132	10	3			32			119	52	8	32	331	453	444	85	1556
1	92	248	134	9	2			11			50	40			139	221	388	28	877
1	93	314	145	16	3		44	45		14	152	64	7	38	592	222	522	172	1872
1	94	214	116	16	3			26		4	62	30	5		175	88	225	72	687
1	95	402	135	76	4			36			11	45	16	14	218	176	374	728	1618
1	96	261	136	6	4	13	57	113		11	204	25	7		336	345	140	11	1262
1	98	327	147	15	4		111	237		29	124	44		27	337	252	280	218	1659
1	99	239	148	11	3			21			56	3		90	513	262	168	80	1193
1	100	283	161	18	4			40			77	29	14	48	123	361	743	172	1607
1	102	155	125	18	2		5	17			3	36	8	43	139	71	134	24	480
1	103	278	156	23	2						55	66		16	347	478	280	194	1436
1	104	255	160	8	4	34	16	94		16	121	7	5	246	525	281	123	16	1484
1	105	228	134	21	4			54			63	26	11		138	127	144	136	699
1	106	203	125	5	4			33		32	100	31	11		372	48	113	30	770
1	107	334	138	13	3		132	150		11	153	54	32	43	281	501	560	312	2229
1	108	180	120	6	2		11	13		5	61	53		69	234	64	84	36	630
1	109	158	107	10	4			21		8	9	38		16	170	35	47	69	413
1	110	137	109	33	2			5		3		10	14		21	42	86	58	239
1	111	140	104	5	4			6		16	15	12	9		71		66	64	259
1	112	155	110	11	3			18			10	7	8		171	16	61	95	386
1	113	207	142	7	3		35	145			68	3	5	43	261	75	91	54	780
1	114	214	126	7	1			36			25	58	23	19	157	200	115	90	723
1	115	165	114	12	4			24		11	51	42	10		128	70	58	89	483
1	116	255	98	39	4		40	86			24	21	10		69	84	228	127	689
1	117	177	105	39	4		12	8			30	12	16		29	45	82	57	291
1	119	198	130	7	3		19	68		19	72	21	10	69	96	109	31	96	610
1	121	169	101	15	3			6		8	21	24		21	123	50	64		317
1	122	172	108	23	4		4	30		11	8	21		16	116	85	7		298
1	123	258	130	7	4	11	67	101			54	49		95	272	234	65	139	1087
1	124	184	114	20	3			18			48	35		27	238	147	81	11	605
1	126	168	113	11	4		8	28			59	10	5	22	149		107	43	431
1	127	153	108	30	4		13				12	35		16	61	110	45	21	313
1	128	152	102	11	2			10		8	6	7	15	55	110	99	34	53	397
1	129	144	100	10	4			10		8	15	25		16	75	59	75	11	294
1	130	144	88	31	1					7	9	15			21	43	42	8	145
1	131	208	126	4	2			129		34	81	17	8	96	249	121	158		893
1	132	152	107	14	3			23		11	23	18			102	50		70	297
1	133	144	110	21	4			23			30		5	16	149	16	34		273

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	VOLUME B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
1	134	143	90	19	3			3			15	7	24		43	16	68	59	235
1	135	158	108	6	3			8			43	46	10		160	49	107	19	442
1	136	124	92	7	4			4		15	9	12	11		102	11	62		226
1	137	214	124	10	3		13	33			89	39	23	11	235	133	88	54	718
1	138	161	107	10	4		27	24		8	28	41	8		127	61	60	68	452
1	139	168	108	7	3			31			47	24	3		123	69	16	91	404
1	140	125	107	5	3		6	15			20	4	5		91	43	16	32	232
1	142	195	130	10	4		11	23			57	10	4	64	196	104	85		554
1	143	196	112	4	2		8	70		27	79	43	14	21	203	77	27	86	655
1	144	255	112	10	4	72	96	213		13	41	5	17	91	144	194	110	49	1045
1	145	237	118	3	4		57	43		16	96	21	5	37	314	186	235	51	1061
1	147	197	113	8	4		11	21		4	35	35	5		151	122	200	123	707
1	148	162	100		3		5	61		22	29	10			134	74	20	15	370
1	149	196	116	8	4	8	18	96			25	48	8	37	152	89	42	54	567
1	150	229	118	6	4		13	57		8	76	59	21	64	218	157	269	56	998
1	151	189	114	2	4		20	62		16	24	24	12	53	85	198	121		615
1	153	209	118	7	4		45	79		22	40	50	8	53	150	176	128	37	788
1	155	227	110	11	4		10	27		22	36	15	5	20	235	297	245	15	927
1	156	158	92	15	4	13	32	18		16	37	10			64	88		31	309
1	157	229	116	13	4		44	38		16	37	13	5	58	68	152	163	34	628
1	158	164	104	22	4			20			7	4			83	61	16		191
1	159	162	101	11	4		14	27		8	30			32	111	73	59	30	384
1	160	226	122	6	4		94	79		11	84	37		16	193	173	298	21	1006
1	161	195	110	6	4		11	111			64	35	13	69	142	172	27	9	653
1	162	273	125	16	4	96	55	90		5	63	34	20	27	339	309	96	83	1217
1	163	151	104		4			34		26	26		5		108	56	48		303
1	164	167	100		4		19	35		24	55	21		22	112		32	32	352
1	165	170	102	10	3			45		16	17	47	8	16	47	155	43	11	405
1	166	115	89		4		3	7		4	10		5		64	22	8	11	134
1	167	175	108		4		44	58		16	14	25		11	96	83	71	12	430
1	168	109	90		4						10	8			60	52	9		139
1	169	84	77		1						4						33	12	49
1	170	141	98		4			22			7	11	8	32	104	32	45		261
1	171	176	108	3	4		40	115			56	20		53	192	33	20	27	556
1	172	214	104	15	4	32	22	75			46	24		48	64	170	50	80	613
1	174	134	90		4			8		4	19	27	4		136	29			227
1	175	215	127	3	4	43	50	78			76	66	11	67	238	190	85	17	923
1	176	195	122	8	4		12	59		8	90	26	10	21	314	93	44	10	687
1	178	253	112	20	4	13	42	112		13	72	45		48	197	178	129	55	904
1	179	239	124	6	4		13	45		8	34	52	21		429	226	260	34	1122

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	B-SEL	C-SEL	D-SEL	I-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
						VOLUME													
1	180	278	116	8	3	67	176	264		11	57	75	32		171	297	146	82	1378
1	181	285	130	22	3	13	107	129			134	102	24		235	343	198	131	1416
1	183	142	93		3			8		5	31	5		37	59	102	48	8	303
1	185	207	87	24	2			13			24	18	11		27	88	94	109	384
1	186	164	93	18	3	6	20	24		11	34	12	3		11	132	66	5	324
1	187	136	95	14	3						14	18	10		16	48	59	11	176
1	188	103	64	20	2			3			3	3	5				11	11	36
1	190	213	110	6	3	26	55	99			23	20	8	21	210	172	28		662
1	192	137	80	36	3		4	11			15	5	5		32	11	32	23	138
1	194	232	108	12	4	42	42	132			137		8	48	171	188	183	23	974
1	195	217	108	6	4		52	79			89	37	5	48	198	179	43	81	811
1	196	216	97	37	4		3	5			28	22	11		47	128	115	73	432
1	197	222	96	11	4		46	55		8	113	6	20	16	160	147	394	12	977
1	199	158	90	41	2		9	20		11	9	3	16	37	11		14	12	142
1	200	159	94	30	3			19			16	9			11	41	67	32	195
1	201	135	84	7	4			5			8	15	14		80		37	32	191
1	202	223	116	12	4	21	34	75			54	30	24	80	231	103	80	23	755
1	203	168	98		4			33			51	13	13	51	32	56	94	9	352
1	204	166	87	11	3		14	14			5	10	20		39	70	76	24	272
1	205	177	101	24	3		8	17			65	22			116	28	9	171	436
1	206	237	114	22	4		7	52		16	29	64	23	21	205	147	119	106	789
1	210	202	104	11	4		51	88		13	54	22	5		154	108	246	25	766
1	211	183	103	3	3		39	47			17	28		48	168	64	83	61	555
1	212	249	109	37	4		12	59				32	9	27	136	94	318	150	837
1	213	311	105	15	3		21	123			224	39	9		288	304	359	32	1399
1	214	228	96	11	4			92		13	49	20	11		214	158	64	29	650
1	216	184	94	26	4		24	52			3	13		43	60	69	25		289
1	217	152	92	5	4	6		13		8	38	10	16		121		16	48	276
1	218	325	149	34	4	68	70	103			62	87	14	27	296	514	418	430	2089
1	219	255	130	20	3		23	100			106	40	13	21	130	249	290	95	1067
1	220	321	153	34		77		48			123	49	8	32	103	341	471	631	1863
1	222	377	139	45	4	77	94	84			25	58	24	93	225	231	649	412	1972
1	223	279	145	29	3	29	70	130		13	59	53	15		57	189	427	194	1236
1	224	342	126	39	3			27			64	65	42	78	268	286	381	442	1653
1	225	133	102	4	4	11	39	23		16	27	15		32	64	43	16	11	297
1	226	181	109	7	4		40	45		17	63	20	5	64	134	100			488
1	228	118	90		4			11		8	21	5		16	111	16	12		200
1	229	94	77		3			4				5	5	9		11	11	11	56
1	230	161	98		4	11	20	37		8	18	8		27	142	53	11		335
1	231	139	97	10	4	5		28		16	27	20	5	43	59	16		22	241

			TOT	PCNT		VOLUME													
STUDY	TREE	DBH	HT	DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
1	232	141	94		4		19	37			33	21	5	32	48	27	32	7	261
1	234	192	107		4		23	76		13	56	24	3	16	219	59	35	11	535
1	235	169	91	13	4		15	35		8	23	36	5	16	102		22	16	278
1	236	112	95		4		11	5		5	17		11	27	27	27	11		141
1	237	105	86	9	4		5				16		6	27	9	32	16	15	126
1	238	136	106	8	2		28	49		8	30	5	8	11	118	16	27		300
1	239	116	86	10	3			7			5	8	5		35	14	32	20	126
1	240	185	108	8	4		11	43		35	92	18		37	123	114	32	33	538
1	241	165	108	3	4		6	34		27	79	4	3	32	85	61	9	27	367
1	242	143	106		4	5	15	37			11	30	3	32	96	43	31	16	319
1	243	117	94		4			10			10	14	9	11	70		45	11	180
1	244	172	108	6	3		24	42			66	42	14		134	94	73		489
1	245	143	86	13	4		16	8		5	16	11	10		36	67	5		174
1	246	106	80	11	3			5		3	8	6	13	21	11		21	11	99
1	247	152	94	4	4		13	47		16	34	32	3	83	64	11	11		314
1	248	139	90	19	4		7	12		6	10	10			39		60	7	151
1	250	235	108	20	4		98	33		11	70	42		64	155	66	89	30	658
1	251	163	105		4		18	51		25	33	29	5	43	87	16	27	7	341
1	252	110	84		4			5		5	3				41			9	63
1	253	107	36	25	4			5		5		3	15		11	21	20	11	91
1	254	158	100	8	4		37	20		8	53	19	15	27	80	64	31	11	365
1	255	200	104	5	3	7	34	87		8	27	39		37	176	128	37	25	605
1	256	174	104		4		28	52		25	21	11	3	91	94	21		22	368
1	257	221	111	4	3		36	74			78	55	3	43	273	86	63	48	759
1	258	281	130		4	13	83	96		48	60	30	49	11	283	411	148	140	1372
1	259	166	104		4		5	34			66	10		32	112	40	19		318
1	260	211	124	5	4		71	61			59	39	5	144	203	145	66	8	801
1	261	199	116	9	1			32		8	5	50	5	37	213	126	70	69	615
1	262	244	136	2	4		80	121		11	105	17		130	346	293	56		1159
1	263	182	120	2	1			26			38	21	4	27	341	118	46	11	632
1	264	190	133	6	2		31	32		11	64	40	5	21	217	107	43	119	690
1	265	168	119	6	3		12	24		11	31	16	5	78	208	79	53	7	524
1	266	216	128	7	4	11	49	90		13	36	8		80	227	118	59	8	701
1	267	226	126	13	2			74		33	39	16	11	16	289	41	135	57	711
1	268	132	100		3					7	8	22	14		54	12	55	49	221
1	269	169	109	5	2	19	36	58	10	28	66	11		20	133	82	21		484
1	270	179	119	3	4	26	35	65		8	47	19		80	124	11	78	11	504
1	271	184	111	10	3		15	24		8	23	34	8	21	105	63	139	126	566
1	273	177	117	6	4	27	43	40			40	10	12		162	69		64	467
1	275	188	117	4	4		13	33			26	42		54	80	21	69		338

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	B-SEL	C-SEL	D-SEL	I-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
						VOLUME													
1	276	147	110	14	4			7			45	8		43	70	74	42	5	294
1	277	184	125	5	4		3	72		8	25	25			186	86	105	9	519
1	276	159	122	21	4			28		5	10	20			141		47	16	267
1	279	237	132	4	4	8	31	129			72	34	5	91	401	160	74	30	1035
1	280	123	107		4			35			18	9			112	25	32		231
1	281	278	135	6	4	51	120	104			134	34		175	346	206	27	40	1237
1	282	147	115	4	4			28	8	8	34		5	48	81	70	37		319
1	283	247	127	18	1		19	71		13	32	25	27	16	139	131	115	174	762
1	284	189	126	5	3		7	72			38	16		27	311	61	80		612
1	285	242	133	9	4		8	27		8	67	44	8	21	366	232	150	79	1010
1	301	185	107	7	3		14	39		5	39	24	3		150	91	64	14	443
1	302	219	108	5	1			8		19	41	14	11		187	213	55	21	569
1	303	143	88	13	3		11			10	17	10	5	16	32	64	16	23	204
1	304	204	114	3	4		21	74		8	22	6	7	107	140	99	105		589
1	305	166	105	6	3		24	23			26	8		64	91	64	44	7	351
1	307	113	98		3			5		5	22				96	11		22	161
1	308	325	120	9	4			20			39	32	50	27	144	175	404	738	1629
1	309	152	81		3			17		15	12	14	5		96	17	43	9	228
1	310	171	101	4	4			53		19	27	5		16	145	64	56	8	393
1	312	156	103	9	1			15			31		4	27	151	27	9		264
1	313	190	106	6	2			4		16	50	11	9	32	182	41	69	23	437
1	314	163	98	4	3			14		11	33	24		37	100	60	54		333

			TOT	PCNT		VOLUME													
STUDY	TREE	DBH	HT	DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
2	1	268	114	23	3		122	71		14	57	107	35	27	91	163	196	45	928
2	2	217	123	37	3		43	69		19	97	49	17	42	176	91	21		624
2	4	362	136	41	3		363	173		30	358	213	105	96	135	147	472	179	2271
2	5	300	123	28	2		170	118			199	140	96		23	215	217	31	1209
2	6	279	126	23	2		219	86		41	84	67	3	80	204	178	17	27	1006
2	7	182	83	20	4		35	6		12	32	31	7		99	16	20		258
2	8	209	99	50	3					5	33	6	9		35		12	14	114
2	9	298	140	18	4		87	61		16	101	76	34		298	283	52		1008
2	10	281	123	10	4		84	44			110	138	8		42	212	385	16	1039
2	11	276	120	22	1		130	120		17	123	74		21	96	320	48		949
2	12	190	105	29			14	36		8	36	19		13	110	88	59	27	410
2	13	325	134	19	4		321	163			98	191	52	32	229	328	193	87	1694
2	14	198	111	22	3		40	30			29	44	32	12	72	122	11	14	406
2	15	289	134	7	4		167	97		43	104	128	16		300	252	64		1171
2	16	303	134	20	2		111	97		2	253	217	71	21	89	372	275		1508
2	17	416	142	18	3		812	167		38	285	202	63	42	236	250	301	119	2515
2	18	301	124	20	3		200	117		8	177	105	26	32	50	474	279	71	1539
2	19	235	106	18	1		18	20		3	73	77	11	27	277	185	59		750
2	20	270	134	22	4		227	142		21	50	134	52		156	161	258	58	1259
2	21	313	144	13	2		54	82		13	273	174	2	66	388	291	247	27	1617
2	22	308	149	14	4		178	47		48	195	143	34		275	310	32	17	1279
2	23	264	140	12	4		144	186		52	145	157	30		237	121	84		1156
2	24	260	120	74	3		12	17			36	74	16						155
2	25	252	130	5	2		101	78		53	167	50		20	81	149	35	43	777
2	26	179	113		4		26	34		31	48	3		48	131		11		332
2	27	118	103		1		2			15	15	3		16	23	38	16		128
2	29	282	130	56	2		98	38		14	118	66	18						352
2	30	180	93	92						9	5					11	9		34
2	31	259	134	21	4		285	195		25	172	56		16	227	48			1024
2	32	196	124	6	3		25	34		3	61			160	176	70	21		550
2	37	208	124	12	4		99	31		34	42	43	12	33	201	75	33		603
2	38	241	127	19			19	22		24	52	43	6	82	265	70		7	590
2	39	178	111	5	2		7	13		20	27	26	28		122	16	88		339
2	40	289	140	10	2		160	14		49	174	80	12		240	285	95	11	1120
2	41	378	150	27	3		174	142		9	161	250	48	28	273	371	204	43	1703
2	44	345	135	22	4		95	60		39	242	259	65		84	196	486	53	1579
2	45	308	129	14	2		219	101		30	151	77	45		178	111	118	166	1196
2	46	381	133	16	3		41	166		32	276	296	69	32	84	547	877	176	2596
2	47	370	136	21	4		155	126		37	284	185	109		77	278	386	84	1721
2	48	379	138	18	3		136	132		38	280	220	42		82	531	691	78	2230

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
						VOLUME													
2	49	185	104	48	2		17	23			39	18			27	74	11	6	215
2	50	347	146	28	4		173	156		22	180	177	59	80	279	473	305	160	2064
2	51	333	144	28	4		91	87		41	233	227	59		138	205	460	211	1752
2	52	357	144	38	4		39	76		9	96	179	39	109	189	284	236	30	1286
2	53	258	124	7	4		100	63		18	91	43	4	47	225	252	48	26	917
2	54	359	118	53	2		178	147		25	151	288	85		56	61	205	149	1345
2	55	359	130	26	3		250	125		102	263	293	103	36	36	290	212	96	1806
2	56	229	130	14	3		93	78		5	164	71	30		51	180	126	75	873
2	58	401	149	49	2		183	229		45	241	430	278		36	89	120	140	1791
2	59	265	127	12			5	14		2	46	157	48	10	160	160	186	53	841
2	60	115	72		2					16	3	5			11	44			79
2	61	376	147	62	3		240	103			87	262	222		8	24	85	86	1117
2	62	355	122	31	3		60	50		22	188	143	60		36	190	442	145	1336
2	63	244	121	37	2		23	41		46	159	12		27	67	67	48		490
2	64	286	119	9	2		46	53		20	59	74	50	27	188	218	38	5	778
2	65	142	85		1		3			12	24	12		21	96	51	32		251
2	66	242	144	4			13	47		21	118	42		107	260	194	69		871
2	67	159	100				4			12	32	10	10		155	70	16		309
2	69	255	116	14			3	18			84	81	18		172	306	100		782
2	70	179	102	21	3		8	16		11	30	9	3	150	111	42	30		410
2	71	240	116	3	4		49	58		35	123	44		67	280	143	107	16	922
2	72	220	125	1	2		13	32		5	102	56		74	214	209	81	27	813
2	73	329	138	16			37	61		9	218	196	73	43	196	553	212	28	1625
2	74	265	118	15	2		6	25			88	78	10		19	257	126	32	641
2	75	425	148	24	3		73	134			451	634	91	14	137	235	750	248	2767
2	76	280	118	9			11	2		7	67	88			347	560	183	42	1307
2	77	306	134	9			78	79		14	180	184	18		152	637	376	59	1777
2	78	225	130	12	1		10	12		27	127	102	7		256	258			799
2	79	224	118	27			4				33	8		16	124	243	107	23	558
2	80	178	104	4	2			8		5	40	27	18		49	106	21	72	346
2	81	201	120	12	2		53	26		9	44	29	53	96	137	88		60	595
2	83	191	113	14			25	22		7	53			43	269	137	43	21	620
2	84	169	114				7	8		50	72	22	12	21	69	90			351
2	85	421	134	47	2		188	99		14	195	301	181		55		107	319	1459
2	86	134	86	8			8			5	8	5			28	8	37	16	115
2	87	271	112	23			25	50		8	100	58	4	56	163	163	198	88	913
2	88	166	73	81	4		5	5			3	5			28	11	12		69
2	89	314	123	29			25				54	58	123		189	243	107	64	863
2	90	245	126	19	1		20	34		36	121	107	43	32	60	140	289	121	1003
2	93	251	118	14	1		25	47		5	108	59	46		103	263	105		761

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	B-SEL	C-SEL	D-SEL	I-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
						VOLUME													
2	94	272	106	80	2		5			3	15	75	32						130
2	95	145	92	18	3			6			20	21	14	16	24		32		133
2	96	295	132	7	4		51	58			115	107	62	80	183	296	235		1187
2	98	169	104	11	4		23	19		29	31	17			54	25	27	39	264
2	99	139	96		3		2			22	44	3	3		14	52	15		155
2	102	229	136	9	4		108	85		25	157	29	29	35	178	158	69	16	889
2	103	169	120	15	2		15	21		14	36	13	18	41	155	9			322
2	104	278	132	29	1		40	60			63	79	100		115	322	211	28	1018
2	105	287	128	21	2		35	34		33	148	115	12	27	114	325	68		911
2	106	160	102		4		18	3			27	22	7	53	72	9			211
2	109	272	112	28	2		12	41		8	78	51	23		128	76	170	55	642
2	110	182	110	12	3		13			49	62	76	15	21	105				341
2	111	192	91					6		11	44	7	5	16	175	21	16		301
2	112	212	104	8	2		4	20		23	28	3			173	142	16	4	413
2	113	150	89	14	3		21			28	44	4			70	44			211
2	115	185	107	12	3		7	36		39	53	21		21	42	89	103		410
2	117	203	122	11	3		130	81		24	61	77	7		159	137	8		684
2	118	217	115	19	3		49	58		19	44	55		21	110	60	31	40	487
2	119	314	118	13	2		229	212		46	89	71	23		148	108	115	66	1107
2	120	178	114	8	3		12	38		20	33	13		37	254	28	18		453
2	122	209	109	8	3		7	18		19	52	24	4	16	103	132	53	16	444
2	123	347	128	51	3		125	163		21	142	254	31		77	188	199	85	1285
2	124	217	122	7	3		51	66		32	104	51		55	93	123			575
2	125	106	50		2		3	3		5	10	18	3		21	7		5	75
2	127	137	74	27	3		9	5		27	5	7			16	33	16		118
2	128	349	134	61	4		68	36		12	65	85	15		16	112	164	120	693
2	129	205	104	11	1		6	38		35	30	16		21	58	80	86		370
2	131	136	72	18	3		3	12		32	26	15				7			95
2	132	182	94	3	3		34	34		36	29		4		220	21			378
2	133	116	59	29	3		4			3	7	5							19
2	134	223	117	5	4		70	77		55	86	17		21	147	200	63		736
2	135	194	99	18	3		61	31		56	30		2		86	37			303
2	136	368	131	59	3		202	51		14	63	277	29		23	117	193	51	1020
2	137	286	122	19	4		277	129		77	136	113	29		27	157	126	4	1075
2	138	170	98	12	2			15		40	66	11			90		29		251
2	139	295	126	36	4		188	132		53	219	229	255	16	30	110	89		1321
2	140	340	124	15	3		142	99		11	143	143	38	46	265	330	115	13	1345
2	141	298	126	31	2		182	154			137	32	20		107	221	98	129	1080
2	142	305	126	16	4		236	158		24	110	47	9		178	185	103	20	1070
2	143	234	104	34	4		32	18		10	20	60		14	165	23	14	14	370

			TOT	PCNT		V O L U M E													
STUDY	TREE	DBH	HT	DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
2	144	297	123	27	2		243	74		55	86	54	23		147	90	62		834
2	145	189	113	11	1		10	17		5	64	22		21	160	99	21		419
2	146	156	94	5	3			8		22	41	11	11		61	28	44	19	245
2	147	131	89	14	2		14	3		27	77	13	6		26				166
2	148	164	95	30	2		6			21	28	9	7		57	38	11		177
2	149	199	105	50	1		25	15		31	37	13			135	56	43		355
2	150	194	102	23	3		27	28		7	30	20		16	107	46	33		314
2	151	175	80	29	1		3			12	20	18	3		64	13			133
2	152	126	83	33	1			5		5	20				20		14		64
2	154	182	107		1			23		2	77	32	11		104	171	72	19	511
2	155	185	111		4		16	6		39	35	10	8		206	87	49	19	475
2	157	183	97	18	3		12	12		17	36	18	3	21	40	62			221
2	158	150	76	44	1		5	12		5	21	3							46
2	159	211	117	27	1		22	35		32	59	46	14		111	89		4	412
2	160	134	73	50	2		3	5		5	7	12			18	7			57
2	161	194	103	8	2		5			8	14	12	5		126	76	42	21	309
2	163	160	108	11	4		15	19		41	26	28	3	35	128	48	123		466
2	164	153	87	12	3		7			36	18	13	5		80	90			249
2	165	186	96	18	1			7		5	33	31			149	51	99		375
2	166	170	102	17	1		4	8		22	51	3	9	14	87	28	35	8	269
2	168	214	111	7	1		41	7		15	36	42	9	43	137	96	64	16	506
2	169	183	102	21	2			14		21	56	23	7	28	177	105			431
2	170	235	116	13	3		49	39		31	55	48	18	23	169	218	4	11	665
2	174	192	113	10	2		57	38		26	22	12		35	205	43	34		472
2	175	196	111	5	2		12	20		8	56	4	8	47	249	132	22		558
2	176	213	114	24	2		17	21		5	36	29			100	133	23		364
2	178	156	85	37	2		13	5			46	28			59				151
2	179	259	119	12	2		56	37		43	116	28	3	50	259	84	16		692
2	180	210	112	3	3		37	19		43	60	49		42	83	65			398
2	181	232	120	5	3		10	16		61	140	137			190	182	21	12	769
2	182	205	120	10	4		54	45		42	72	3	4		330	104	8	16	678
2	183	177	117	3	4		24			42	39	12	5	21	117	131	5	32	428
2	184	193	116	3	4		40	43		39	74	35	3	16	121	36	36	16	459
2	185	253	123	12	4		53	58		23	147	42	12	27	194	273	49	5	883
2	186	212	118	7	3			45		43	93	41	12		193	82	74		583
2	187	369	144	62			46	15			131	120	64	27	55	361	168	48	1035
2	188	215	115	2	4		14	40			88	100		80	230	86	7		645
2	189	291	122	8	2		36	25		17	97	47	4	14	52	426	151	43	912
2	190	190	116	9	4		8			23	45	24	5	21	194	46	16		382
2	191	176	114	3	4		39	38		100	89	17		14	89	16			401

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
						V O L U M E													
2	192	194	124	5	4		35	72		81	40	34	5	21	162	7		40	497
2	193	184	104	7	3		30	35		54	41	11	2	21	78	24	7		303
2	195	320	132	16	4		98	98		20	247	38	2	60	311	235	410	30	1549
2	196	351	136	21	1		8	12		6	229	176	50	14	133	434	503	174	1739
2	197	285	133	17	1		53	136		48	146	146	9	64	300	191	104		1197
2	198	233	121	13	3		74	71		35	132	49	11	70	156	144	58		800
2	199	132	84	45	1			2		8	21		5	28			8		72
2	200	118	82		2						14			16	16	7			53
2	201	225	122	6	3		96	99		108	160	24		53	53	120	43		756
2	202	288	137	14	4		268	86		94	149	140	11	43	138	311	19		1259
2	203	261	117	10	3		185	104		16	140	122	3	16	270	201	21		1078
2	204	287	121	18	4		131	73		13	259	180	47		27	226	164	14	1134
2	205	202	107	19	4		61	11		42	35	4		14	183	68			418
2	206	311	124	28	2		112	173		32	202	125	60		212	575	96	21	1608
2	207	275	117	12	3		40	84		48	153	125	2	27	262	396	149	53	1339
2	209	282	126	20	3		27	49		16	198	142	20		20	168	449	95	1184
2	210	341	129	18	4		172	120		19	189	102	130		5	348	429	342	1855
2	211	210	102	18	4		29	21			49	41			82	57	29	21	329
2	212	217	100	15	3		19			6	11	50	9		155	30			280
2	213	145	99	15	3		8	23		43	58	20				16			168
2	214	129	97	14	2		3	16		20	43	8	2	32		23	11		158
2	215	320	124	25	4		231	124		50	116	233	78		88	264	164		1348
2	216	171	103	3	3		26	6		8	31	35		16	90	54		7	273
2	217	206	95	23	4		56	28		26	35	22	5	96	101				369
2	218	390	146	42	1		60	80		16	162	237	96		64	230	290	217	1452
2	219	339	140	34	1		92	43		13	219	181	37		252	480	113	75	1505
2	220	262	129	12	3		31	57		39	36	60		35	370	356	28		1012
2	221	249	96	29	2		21	18			31	75	10		33	139	109		436
2	222	375	129	40	2		65	51		3	107	246	164		47	77	582	222	1564
2	223	308	127	30	4		181	142		25	108	56	5	32	334	161	64		1108
2	224	266	120	23	4		145	72		23	92	101	22	27	96	178	37	11	804
2	225	223	114	11	4		59	57		46	34	22		53	261	83	66	23	704
2	226	420	134	39	2		369	109		18	149	106	83	18	40	45	409	260	1606
2	227	299	124	19	4		275	132		90	152	48		70	228	387	156		1528
2	228	301	130	19	4		161	70		111	189	35	13	43	236	227	114		1199
2	229	218	117	16	3		168	53		83	160	34	49	21	149	64		4	785
2	230	204	110	22	3		8	75		26	60	21			122	70	16	53	451
2	231	254	126	19	4		252	81		24	187	48	14		51	61	96	74	888
2	232	206	103	21	3		40	26			36	37	5		100	90	112	40	486
2	233	210	100	16	2		11	21		60	96	2			91	106	29	5	421

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	VOLUME B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
2	234	290	120	24	1		126	112		19	96	66	11	42	226	170	56		924
2	235	310	133	7	4		212	68		59	144	78	4	21	249	202	150	11	1198
2	236	174	120	13	3		61	51		13	25	39		16	214		8		427
2	237	239	114	17	1		41	57		3	75	6	15	27	207	99	57		587
2	239	309	132	6	3		271	161		57	141	111	16		145	358	75		1335
2	240	271	130	15	4		128	73		13	119	106		64	330	274			1107
2	241	152	73	28	1			7			58	23			59	11	14		172
2	242	198	119	5	4		40	19		49	58	2	5	32	187	53			445
2	243	215	124	7	4		117	98		29	105	93		23	199	147	96	4	911
2	244	264	114	4	4		40	88		46	180	59		21	178	127	5		744
2	245	186	117	12	4		33	15		9	97	25	2	16	177	16	27		416
2	246	412	144	64	3		100	118		25	226	467	155			62	174	88	1415
2	247	137	110	4	4		15	17		68	35	7	11		92				245
2	248	175	110	5	4		79	41		42	63	5		21	79	21		16	367
2	249	320	143	13	3		214	134		41	180	150	32	28	438	471	161	53	1902
2	250	216	126	11	3		72	38		21	74	39		48	274	129	14		709
2	251	178	110	9	3		20	16		50	75	16		21	112	40			350
2	252	323	128	11	4		118	121		82	284	171	55		132	165	73	11	1212
2	254	288	118	25	4		42	74		19	180	168	52	74	73	163	336	45	1226
2	255	196	115	22	3		21	15		15	88	36	42		16	45	64	21	363
2	256	183	116	13	3		17	21		75	58	12	5	21	156	64	18		447
2	257	187	115	3	3		52	68		60	32			61	174	19			466
2	258	208	120	2	3		41	62		116	53				162	95	21		550
2	259	199	121	19	2		37	26		135	99	25			150	28	18		518
2	261	279	117	19	4		9	68		11	116	67	9	50	80	244	43		697
2	262	305	128	34	3		18	38			167	153	58		55	359	135		983
2	263	113	83		3		14	3		33	12						11		73
2	264	144	90		1			8		12	30	13		37	76	48	15		239
2	265	146	89	20	1			3		17	31	5		16	14	39	16		141
2	266	138	77	33	1			3		5	3	11					20		42
2	267	131	72	8	2		14	12			15				22	60	7		130
2	268	115	83	17	2		5			10	20	4				11			50
2	269	127	76	23	3		7	4		17	28	11			44				111
2	270	109	67	17	3			6		7	15	3				14	5		50
2	271	131	70	12	3		5	5		27	33	13							83
2	272	144	85	6	3		8			7	15			16	69	11	44	7	177
2	273	182	83	3	4		37	29		41	41	19		19	85	64			335
2	274	147	84	6	1		31			17	29	10		16	16	9	32		160
2	275	134	78	18	3		2	3		23	27	7	3		25	24			114
2	276	168	88	12	3		32	29		26	60	16			64	16	48	8	299

STUDY	TREE	DBH	TOT HT	PCNT DEF	NLF16	B-SEL	C-SEL	D-SEL	1-COM	2-COM	3-COM	4-COM	5-COM	S-STR	CONST	STAND	UTIL	ECON	TOTAL
						VOLUME													
2	277	145	76		3		25	8		52	3	14			8	14			124
2	278	114	79	12	2		14	5		27	33		4		14	7	9		113
2	279	148	88		3		3	27		26		12		16	69	32			185
2	280	125	87		4		21	5		3	19			16	16	20			100

Appendix III

INSTRUCTIONS FOR MEASURING TREE CHARACTERISTICS

Instructions for measuring and recording the western larch tree characteristics used in the equations are shown below.

1. *Tree diameter (D)* is measured and recorded to the nearest 0.1 inch at 4-1/2 feet above ground on the uphill side on the tree.

2. *Tree height (H)* is total tree height measured from the ground on the uphill side of the tree and recorded to the nearest foot. This height includes a dead top if one exists and the projected height if the tree has a broken top.

3. *Number of limb-free and defect-free faces in the butt 16-foot log (NLDF16)*, where a face is one-fourth the circumference of the tree for the full 16-foot length of the butt 16-foot log (butt 16-foot log defined as the first 16.5 feet of the tree above normal stump height). Any limb or limb stub other than epicormic limbs removes a face. Any scalable defect removes the face in which the defect occurs. All size knot indicators are allowed. The variable is coded as 0-4 faces.

4. *Scalable defect (DEF)* is expressed as a percent of the gross cruise volume. The estimate includes deductions made from the gross cruise volume for visible abnormalities such as crook, conks, cankers, burls, and bumps. It also includes the estimated volume loss from unknown sources such as logging breakage and hidden or internal defects such as rot or pitch rings.

GPO 985-451

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1978. An equation for estimating the value and volume of western larch trees. USDA For. Serv. Res. Pap. PNW-231, 29 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

This paper describes an equation for estimating the total sales value or the volume for western larch trees. The equation requires four easy-to-measure characteristics. Both the development and the application of the system are discussed.

KEYWORDS: Tree value, volume estimation, grading systems, western larch, *Larix occidentalis*.

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2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

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